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Tumors of the Thyroid Gland in Teleost Fishes[1]

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(Plates I & II)

TUMORS of the thyroid gland have been investigated more thoroughly than most other types of teleostean tumors, principally because of the economic value of many of the fishes involved and the similarities to goitrous conditions in man. The genetic and environmental bases for atypical thyroid growth in fishes are still not fully understood, however. The study of this condition also may throw light on the elusive problem of the normal functions of the fish thyroid. Since 1948, thyroid tumors have been under study in poeciliid fishes maintained in the Genetics Laboratory of the New York Aquarium. Recently we had the opportunity to study, in *Girardinus falcatus* and *Xiphophorus variatus variatus,* thyroid tumors that exhibited some characteristics different from the ones reported in other poeciliids. As part of this study, all known cases of thyroid tumors in teleosts were reviewed, with special reference to the influences of heredity and environment.

Atypical Thyroid Growths in *Girardinus falcatus*

When several *Girardinus falcatus*[2] from a stock kept at the John G. Shedd Aquarium in Chicago were received in the Genetics Laboratory in 1957, their gill regions were seen to be markedly swollen. Two immature females, measuring 18 mm. in standard length, were selected for histological study. The remaining fish were placed in a five-gallon aquarium, the water of which was supplemented with several drops of potassium iodide. Within a month the external swellings had disappeared. About four months later, one of these live-bearing fish produced a brood which was reared in iodine-enriched water. Two of the offspring, an immature male and an immature female, were sacrificed when 18 mm. long for the purpose of comparing their thyroidal tissues with those of the two fish with indications of thyroid hyperplasia. The fish were fixed in Bouin's fluid, decalcified in formic acid, embedded in paraffin and serially sectioned at 10 microns. Staining was with Masson's trichrome.

Microscopic Appearance of Normal Thyroid Tissue

The thyroid tissue consisted of isolated follicles located mainly around the ventral aorta, especially at the bases of the aortic arches (Fig. 1). In any single cross-section, no more than ten follicles were present. The follicles extended anteriorly in the floor of the mouth slightly anterior to the first aortic arch, at the level of the posterior part of the lens of the eye. Posteriorly, they extended around the ventral aorta to a level slightly anterior to the auricle. No follicles were found in the gills. The follicles ranged from 10 to 80 microns in diameter. They contained dense homogeneous colloid that stained bright red or, in certain follicles, purple with Masson's trichrome. The cuboidal epithelial cells forming the follicles were 2 to 6 microns in height; their nuclei were oval, with a single nucleolus.

Microscopic Appearance of Hyperplastic Thyroid Tissue

The thyroid follicles were greatly increased, both in number and size. A typical cross-section through the pharyngeal region contained several

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[2]Formerly classified in the genus *Glaridichthys* (Rosen & Bailey, 1959).

hundred follicles (Fig. 2). The follicles extended anteriorly along the floor of the mouth well in front of the first aortic arch. Posteriorly, they extended along the floor of the pharynx and around the ventral aorta and inferior jugular veins to the auricle. Dorsally, the enlarged tongue consisted almost entirely of thyroid tissue. Ventrally, the follicles had spread through the muscular mass of the lower jaw and between the elements of the visceral skeleton. Laterally, they had spread into the gills, often to the tips of the gill filaments (Fig. 3). No heterotopic thyroid tissue was present in the kidneys or elsewhere in the body.

The follicles often appeared to follow the course of blood vessels, but no evidence of invasion of the walls of these vessels or of pronounced pressure on these vessels was seen. The proliferating thyroid tissue had, however, caused the gill epithelium to pull away from its vascular and skeletal elements at some points; the involved secondary gill filaments were enlarged and showed evidence of various degrees of pressure against one another. Some of the anterior branchial epithelium was replaced by thyroid tissue, and respiration probably had been considerably impaired. Some of the deep musculature of the lower jaw had apparently degenerated. Bone and cartilage were essentially normal.

Most of the thyroid tissue was arranged in follicles. There was great variation in follicle size—from 10 to 300 microns in diameter. The lumen in most cases was filled with dense homogeneous colloid that stained bright red with Masson's trichrome or, in certain follicles, purple. In some cases the lumen was filled with granular colloid that stained gray. Other follicles contained no colloid. The epithelial cells forming the follicles were mostly cuboidal (some were low columnar) and ranged from 3 to 8 microns in height. The nuclei were oval, with a single nucleolus (Fig. 4). Some afollicular thyroid cells were present. No mitoses were found. The growth was highly vascularized.

Girardinin Iodine Requirements

The second generation offspring produced by some of the original fish obtained from the Shedd Aquarium were reared in the Genetics Laboratory in relatively iodine-poor water. In the same water (aquarium water in which, over a period of several years, evaporation loss had been made up by the addition of distilled water, rather than tap water) members of certain strains of *Xiphophorus maculatus* had developed thyroid tumors both in the pharyngeal area and in the kidney. None of the girardinins, however, developed any external evidence of abnormal thyroid growth. Histological examination of two 20-mm. fish showed normal thyroid tissue. From this it appears that the iodine requirement of girardinins is not as high as that of platyfish. If this is correct, it is probable that the water in aquaria in the Shedd Aquarium was extremely low in iodine. Despite their hyperplastic thyroid tissue, these *Girardinus* have been maintained for many generations at the Shedd Aquarium.

Thyroid Tumor in *Xiphophorus variatus variatus*

The specimen was an adult male *Xiphophorus variatus variatus* from the first laboratory-reared generation of fish collected in 1957 from the Rio Necaxa, Mexico. Of 8 fish reared together in the same tank, this was the only one with a visible thyroid tumor. Its standard length was 35 mm. Externally the entire body was swollen. The specimen was fixed in Bouin's fluid, decalcified in formic acid, embedded in paraffin and serially sectioned at 10 microns. Staining was with Harris' hematoxylin and eosin.

Microscopic Appearance

The pharyngeal thyroid was markedly hyperplastic. The thyroid tissue had spread anteriorly along the floor of the mouth well in front of the first aortic arch, posteriorly around the ventral aorta, and laterally into the bases of the gills. It consisted of follicles of varying sizes and of afollicular tissue (Fig. 5). A number of the follicles were filled with eosinophilic colloid, which often was vacuolated. The thyroid cells were hypertrophied; some contained eosinophilic droplets at the end distal to the lumen.

Large quantities of thyroid tissue were found in the spleen and in the body cavity among the pancreatic tissue and intestines. The spleen was no longer a discrete organ, its walls being penetrated by thyroid tissue, and only a small amount of normal splenic tissue could be found. The other body organs appeared normal, despite the large amount of thyroid tissue in the body cavity. There is a possibility that the thyroid tissue had first been located in the spleen and later burst into the body cavity. No thyroid tissue was found in the kidney. The distribution of thyroid tissue in this specimen differs markedly from that in *X. maculatus,* in which heterotopic tissue appears first, and is most abundant, in the kidney, is frequently located in the spleen, but has not been found in the body cavity (Baker, 1958a).

The thyroid tissue in the spleen and body cavity generally consisted of follicles of varying sizes, some very large (Fig. 6). Most of the follicles contained a scant amount of eosinophilic colloid. The cells forming the follicles ranged from cuboidal in the larger follicles to high columnar in the smaller ones; most of them contained eosinophilic droplets at the end distal to the lumen (Fig. 7).

Discussion

Tumors of the thyroid gland have been reported in more than 40 species of teleosts. The first report was by Bonnet in 1883; the most recent comprehensive review of the literature was by Schlumberger & Lucké in 1948.

It is often difficult to distinguish between a simple goitrous response to environmental conditions and a malignant growth, even in animals where the thyroid is encapsulated (Willis, 1953). It is especially difficult in teleost fishes, where the thyroid tissue is generally not encapsulated. Hyperplastic thyroid tissue in fish can readily invade surrounding tissue and also migrate to the kidney and other body organs (Baker 1958a, 1958b, 1959; Baker-Cohen, 1959), causing death of the animal by pressure on the gills and body organs. Histologically, it is often not possible in fishes (Lucké & Schlumberger, 1949) or in other vertebrates (Willis, 1953) to distinguish between a simple hyperplastic condition, a non - malignant tumor (adenoma), and a true neoplasm (adenocarcinoma). Most thyroid tumors in fish regress when the animal is treated with iodine and thus should be classified as goiters; however, some of these growths do become malignant, although there are differences of opinion among investigators as to how frequently this occurs (Lucké & Schlumberger, 1949). There is general agreement that, in all vertebrates, goiter predisposes to and usually precedes adenoma and adenocarcinoma (Willis, 1953; Crile, 1958). Schlumberger (1955) stated that "cancer of the thyroid occurs under the same conditions and in the same animal species as does thyroid hyperplasia and goiter." In the present paper, all spontaneous thyroidal growths that appear to be atypical and not normal physiological fluctuations are considered.

Thyroid Tumors in Nature

The records for most types of fish tumors show that the majority have been obtained from specimens that were living in their natural habitat (Lucké & Schlumberger, 1949). Thyroid tumors form a notable exception, being relatively rare in nature. They have been reported in only 12 species (Table I), and most of these are represented by a single tumorous individual. Many are associated with low iodine conditions. The longear sunfish came from the Scioto River, Ohio, which has an iodine content of only .21 μg per kg/water, as compared with .83 μg in the Mississippi River (Schlumberger, 1955). The brook trout and whitefish from New York and the Atlantic salmon from Maine reported by Gaylord & Marsh (1914) came from waters in populated regions and possibly had been planted from hatcheries, which at that time did not supplement their diets with iodine.

In the Great Lakes area, a well-known goiter belt, Marine & Lenhart (1910a) found goiters in fishes from four families. Robertson & Chaney (1953) reported marked thyroid hyperplasia in rainbow trout inhabiting this area, with the exception of some fish that had access to additional iodine discharged from the holding ponds of a nearby hatchery. These authors also studied the same species in coastal streams of California and found no evidence of hyperplasia.

Takahashi (1934) examined 100,000 marine fishes and found 154 tumors, none involving the thyroid. This may be considered typical, for, despite the great numbers of marine teleosts taken for food and among which tumors of all types have been recorded, thyroid tumors have been found in only two specimens—a cutlass fish and a bogue. These, however, are sufficient to indicate that factors other than iodine deficiency may be operative in thyroid hyperplasia.

Spontaneous Thyroid Tumors in Captivity

The great majority of fishes with thyroid tumors have been found in hatcheries, public aquariums and research laboratories (Table II). Among conditions that may occur in captivity, the following have been suggested as agents inducing thyroid hyperplasia: iodine deficiency (Marine & Lenhart, 1910b; many other investigators), low oxygen tension (Duerst, 1941), changes in light intensity (Rasquin & Rosenbloom, 1954), decreased salinity (Olivereau, 1948), altered calcium-magnesium ratio (Nigrelli, 1952), increased activity forced on captive fish by tankmates (Nigrelli, 1952), an infectious agent (Gaylord & Marsh, 1914). Of these factors, iodine has received the greatest emphasis. The concentration of iodine in aquaria sometimes becomes quite low because of extraction by algae, snails and fishes (Berg, Gordon & Gorbman, 1954). Most thyroid tumors in teleosts can be prevented or induced to regress by adding iodine to the water; for example, Pickford (1953) reported that thyroid hyperplasia in *Fundulus* maintained in sea water can be prevented by the addition of iodine. Presumably, the lack of iodine leads to a deficiency of thyroxine in the blood, which in turn results in an increased secretion of thyrotropin (TSH) by the pituitary gland, which causes hyperplasia of the thyroid gland (Pickford, 1957). Similarly, decreased oxygen tension or a stress factor may place an increased demand upon the thyroid and lead to hyperplasia. The addition of iodine may not only compensate for a deficiency in the environment but may, by making possible an increased production of thyroxine, counteract factors such as low oxygen tension.

Hereditary Differences in Susceptibility to Spontaneous Thyroid Tumors

That heredity influences the thyroid tumors of fishes seems well established. Under identical environmental conditions, certain species and strains show considerably greater susceptibility to these atypical growths than do others. In their extensive study of salmonoid fishes in hatcheries, Gaylord & Marsh (1914) stated that certain species, as well as certain lots among susceptible species, showed a high degree of immunity. The brown and rainbow trout at one hatchery developed into resistant strains during a 25-year period. Hybrids of brook trout with landlocked salmon and sunapee trout were similar to the parental strains; *Oncorhynchus* hybrids, however, generally showed much more susceptibility to thyroid disease than either parental strain. Marine & Lenhart (1910a) reported that the lake pike and white bass in Lake Erie were "very commonly" found with goiters, but the lake herring and sheepshead rarely, and the carp never.

Of 400 species of small, tropical freshwater fishes under observation in the New York Aquarium from 1931 to 1936, only two, *Rasbora lateristriata* and *Heterandria formosa*, were found with thyroid tumors (Smith & Coates, 1937). At the Fairmount Park Aquarium in Philadelphia, where Schlumberger & Lucké (1948) found thyroid tumors in several shark suckers, no thyroid tumors were found in other marine fishes kept under identical conditions, or

TABLE I. THYROID TUMORS IN TELEOSTS IN NATURE

Species[1]	Reference
Family Clupeidae	
Landlocked Alewife, *Pomolobus pseudoharengus* (Great Lakes, U.S.A.)	Hoar (1952)
Lake Herring, *?Pomolobus pseudoharengus* (Lake Erie, U.S.A.)	Marine & Lenhart (1910a)
Family Salmonidae	
Atlantic Salmon, *Salmo salar* (Sebago Lake, Maine, U.S.A.)	Gaylord & Marsh (1914)
Brown Trout, *Salmo trutta* (Moon Lake, Austria)	Hofer (1904)
Trout, ?*Salmo trutta* (streams in Bavaria)	Plehn, in Gaylord & Marsh (1914)
Rainbow Trout, *Salmo gairdneri* (Naini Tal, India; Great Lakes area, U.S.A.)	Southwell (1915), Robertson & Chaney (1953)
Brook Trout, *Salvelinus fontinalis* (Hosmer's Creek, New York, U.S.A.; Algonquin National Park, Ontario, Canada)	Gaylord & Marsh (1914)
Family Coregonidae	
Lake Whitefish, *Coregonus clupeaformis* (Lake Keuka, New York, U.S.A.)	Gaylord & Marsh (1914)
Family Esocidae	
Lake Pike, ?*Esox lucius* (Lake Erie, U.S.A.)	Marine & Lenhart (1910a)
Family Trichiuridae	
Cutlass Fish, *Trichiurus lepturus* (off the south coast of Portugal)	Pinto (1958)
Family Serranidae	
White Bass, ?*Lepibema chrysops* (Lake Erie, U.S.A.)	Marine & Lenhart (1910a)
Family Sparidae	
Bogue, *Box boops* (trawled near Trevose, England)	Johnstone (1923)
Family Centrarchidae	
Longear Sunfish, *Lepomis megalotis* (Scioto River, Ohio, U.S.A.)	Schlumberger (1955)
Family Sciaenidae	
Sheepshead, ?*Aplodinotus grunniens* (Lake Erie, U.S.A.)	Marine & Lenhart (1910a)

[1]Scientific and popular names are those in present usage. Scientific names preceded by a question mark have been inferred from the popular name, which was the only one given and which is not necessarily the one used most widely today.

in any of the freshwater fishes, during the same 12-year period. The goldfish (*Carassius auratus*) exhibits many types of tumors, but only one thyroid tumor has ever been reported in this frequently studied species (Nigrelli, 1954).

In the Genetics Laboratory of the New York Aquarium, where various fishes of the genus *Xiphophorus* have been maintained in water of low iodine content, tumors have been commonly observed in *X. montezumae cortezi, X. pygmaeus pygmaeus* and in most strains of *X maculatus.* Such tumors have been rare in *X. variatus variatus* and *X. variatus xiphidium* and have never been observed in *X. couchianus,* three subspecies of *X. helleri,* and one strain of *X. maculatus.* The latter is our strain "30," which has been inbred brother-to-sister for 29 generations; its ability to live in low-iodine water with no perceptible difficulty may well have been selected for during the 15 years of its existence before iodine supplements to aquarium water became routine in the Laboratory. The pattern of tumor development also varies among the species. In *X. maculatus* the thyroid in the throat area is moderately hyperplastic, but extensive tumors appear in heterotopic locations such as the kidney and spleen. In *X. montezumae cortezi* there are large tumors in the throat, but heterotopic tumors are very rare (Baker, 1959).

Berg, Edgar & Gordon (1953), who studied the differences in thyroid tumors between two strains of *X. montezumae cortezi,* suggested that the enhanced tumor development in the more inbred strain was the result of an increasing homozygosity of multiple factors. Baker (1958a) made crosses between resistant and susceptible strains of *X. maculatus;* she came to the provisional conclusion that multiple genetic factors were involved and that the factors promoting tumor development had some degree of dominance. Additional crosses are now being made in the Genetics Laboratory to study the genetics of susceptibility to thyroid tumors.

Experimentally-induced Thyroid Tumors

Observations of spontaneous tumors are paralleled by experimental studies. Pickford (1957) summarized the effects of anti-thyroid drugs on 23 species of marine and freshwater teleosts. In the marine forms, there was generally a lower degree of reactive hyperplasia than in the freshwater ones. Anti-thyroid drugs had little or no effect on the thyroid of the goldfish; as noted above, spontaneous thyroid tumors appear to be very rare in this species.

Physiological Genetics of Thyroid Tumors

The physiological mechanisms by which genetic differences operate remain to be elucidated. Undoubtedly, fishes differ in their iodine requirements or metabolic needs for iodine. Berg, Gordon & Gorbman (1954) pointed out that a concentration of 2.3 μg/liter of iodine was sufficient to prevent tumor formation in *X. montezumae cortezi,* whereas in rainbow trout, a species in which many thyroid epidemics have been reported, at least 5 μg/liter was necessary, according to the data of Robertson & Chaney (1953). Our studies indicate that *G. falcatus* has a low iodine requirement.

Iodine requirements are presumably closely related to thyroid function. The thyroid gland may play a more active role in certain fishes than in others. Unfortunately, little is definitely known about the functions of the piscine thyroid (Pickford, 1957; Gorbman, 1959; Harris, 1959). If the thyroid plays a role in such processes as osmoregulation, temperature regulation or sexual maturation, the iodine requirements—and therefore, we assume, susceptibility to thyroid hyperplasia—would differ according to the ecology of a fish and would also vary during its ontogeny. At the time of reproduction, thyroid hyperplasia occurs in some landlocked species in the Great Lakes area, *e.g.*, the alewife (Hoar, 1952) and the rainbow trout (Robertson & Chaney, 1953)—a condition not found in their marine counterparts. It does not, however, occur in the landlocked smelt, *Osmerus mordax* (Hoar, 1952). Pink and chum salmon fry when retained in fresh water beyond the time of their usual migration to the sea developed hyperplastic thyroids(Hoar & Bell, 1950), which Hoar (1959) interpreted as due partially or wholly to a deficiency of iodine, since the condition could be prevented by an iodine-rich diet.

It has been suggested that metabolic level is important and that active species with high oxygen requirements are more susceptible to thyroid hyperplasia (Schlumberger, 1955; Pickford, 1957). In this connection, Pickford pointed out that at least some of the marine species that have been treated with anti-thyroid drugs are sluggish in their habits, whereas most of the freshwater species are highly active, the sluggish goldfish being a significant exception. Duerst (1941; reviewed by Schlumberger & Lucké, 1948) presented experimental evidence that active fishes, such as trout, require a greater quantity of oxygen for proper functioning of the thyroid than do inactive ones, such as carp, the former developing hyperplasia at low oxygen concentrations.

In addition to differing body demands for thyroid hormone, genetic differences may involve many other factors, such as the efficiency of iodine-trapping mechanisms, the processes of

TABLE II. SPONTANEOUS THYROID TUMORS IN TELEOSTS IN CAPTIVITY

Species[1]	Reference
Family Clariidae	
African Catfish, *Clarias dumerili*	Schreitmüller (1924)
Family Salmonidae	
Atlantic Salmon, *Salmo salar*	Gilruth (1902), Gaylord & Marsh, (1914)
Salmon, ?*Salmo salar*	Crettiez, in Jaboulay (1908), Peyron & Thomas (1930)
Brown Trout, *Salmo trutta*	Bonnet (1883)[2], Gaylord & Marsh (1914)
Trout, ?*Salmo trutta*	Jaboulay (1908), Peyron & Thomas (1930)
Rainbow Trout, *Salmo gairdneri*	Gilruth (1902), Gaylord & Marsh (1914), Leger (1925)
Brook Trout, *Salvelinus fontinalis*	Scott (1891), Pick (1905)[2], Marine & Lenhart (1910b, 1911), Marine (1914), Gaylord & Marsh (1914)
Char, ?*Salvelinus alpinus*	Crettiez, in Jaboulay (1908)
Lake Trout, *Salvelinus namaycush*	Gaylord & Marsh (1914)
Lake Trout, ?*Salvelinus namaycush*	Smith (1909)
Pink Salmon, *Oncorhynchus gorbuscha*	Gaylord & Marsh (1914)
Several salmonid species	Plehn (1902[2], 1912)
Hybrids	
Trout, ?*Salmo trutta* × Char, ?*Salvelinus alpinus*	Crettiez, in Jaboulay (1908)
Brook Trout, *Salvelinus fontinalis* × Sunapee Trout, *Salvelinus aureolus*	Gaylord & Marsh (1914)
Brook Trout, *Salvelinus fontinalis* × Landlocked Salmon, *Salmo salar sebago*	Gaylord & Marsh (1914)
Silver Salmon, *Oncorhynchus kisutch* × Pink Salmon, *Oncorhynchus gorbuscha*	Gaylord & Marsh (1914)
Silver Salmon, *Oncorhynchus kisutch* × King Salmon, *Oncorhynchus tshawytscha*	Gaylord & Marsh (1914)
Blueback Salmon, *Oncorhynchus nerka* × Pink Salmon, *Oncorhynchus gorbuscha*	Gaylord & Marsh (1914)
Family Cyprinidae	
Pearl Danio, *Brachydanio albolineatus*	Klemm (1927)
Zebra Danio, *Brachydanio rerio*	Roth (1913)
Danio, ?*Brachydanio* sp. or *Danio* sp.	Plehn (1920), Schreitmüller (1924)
Rasbora lateristriata	Smith, Coates & Strong (1936), Smith & Coates (1937)
White Cloud Mountain Fish, *Tanichthys albonubes*	Stolk (1956a)
Cherry Barb, *Barbus titteya*	Baker (1959)
Barb, ?*Barbus* sp.	Schreitmüller (1924)
Iraqi Blind Cavefish, *Typhlogarra widdowsoni*	Olivereau, in Baker (1959)
Goldfish, *Carassius auratus*	Nigrelli (1954)
Family Cyprinodontidae	
Killifish or Mummichog, *Fundulus heteroclitus*	Nigrelli (1952), Pickford (1953)
Redjaw Killy, *Epiplatys chaperi*	Klemm (1927)
Sheepshead Minnow, *Cyprinodon variegatus*	Nigrelli (1952)
Flagfish, *Jordanella floridae*	Schreitmüller (1924), Müller (1926)
Aphanius sophiae	Weissenberg (1922), Susebach (1922)
Family Poeciliidae	
Montezuma Swordtail, *Xiphophorus montezumae cortezi*	Gorbman & Gordon (1951), Berg, Edgar & Gordon (1953), Berg & Gorbman (1954), Berg, Gordon & Gorbman (1954), Baker (1959)

TABLE II. SPONTANEOUS THYROID TUMORS IN TELEOSTS IN CAPTIVITY *(Continued)*

Species[1]	Reference
Pygmy Swordtail, *Xiphophorus pygmaeus pygmaeus*	Berg, Edgar & Gordon (1953)
Common Platyfish, *Xiphophorus maculatus*	Berg, Gordon & Gorbman (1954), Baker, Berg, Gorbman, Nigrelli & Gordon (1955), Baker (1958a, 1958b), Baker-Cohen (1959)
Spike-tailed Platyfish, *Xiphophorus variatus xiphidium*	MacIntyre & Baker-Cohen, ms.
Variatus Platyfish, *Xiphophorus variatus variatus*	MacIntyre (1960)
Guppy, *Poecilia* (= *Lebistes*) *reticulata*	Vivien & Ruhland-Gaiser (1954)
Mosquito Fish, *Heterandria formosa*	Smith, Coates & Strong (1936), Smith & Coates (1937)
Yellow Belly, *Girardinus falcatus*	MacIntyre (1960)
Family Serranidae	
Serranus scriba	Marsh & Vonwiller (1916)
Comber, *Serranus cabrilla*	Marsh & Vonwiller (1916)
Family Anabantidae	
Climbing Perch, *Anabas scandens*	Southwell & Prashad (1918), Plehn (1920)
Family Chaetodontidae	
Blue Angel Fish, *Angelichthys isabelita*	Nigrelli (1952)
Family Cichlidae	
Jack Dempsey, *Cichlasoma biocellatum*	Stolk (1956b)
Family Echeneididae	
Shark Sucker, *Echeneis naucrates*	Schlumberger & Lucké (1948), Schlumberger (1955)

[1]Scientific and popular names are those in present usage. Scientific names preceded by a question mark have been inferred from the popular name, which was the only one given and which is not necessarily the one used most widely today.

[2] Cited by Gaylord & Marsh (1914).

thyroid hormone synthesis and secretion, the activities of the pituitary gland, or the sensitivity of thyroid tissue to thyrotropin. For example, Berg & Gorbman (1954) showed that the thyroids of tumerous *X. montezumae cortezi* produced thyroxine much more slowly than did the glands of normal species.

SUMMARY

Several cases of spontaneous hyperplasia of the thyroid gland in the poeciliid fish, *Girardinus falcatus*, in which thyroid tissue had invaded the gills, are described; this condition was relieved by the addition of iodine to the aquarium water. A thyroid tumor in a specimen of *Xiphophorus variatus variatus* is described in which extensive growths were found in the pharyngeal area, spleen and body cavity. Many reports of spontaneous thyroid tumors in teleost fishes in captivity and a few in nature have been made. These are listed and discussed, with particular reference to the strong evidence for genetic susceptibility to this condition.

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EXPLANATION OF THE PLATES

PLATE I

Girardinus falcatus

FIG. 1. Normal thyroid tissue around the ventral aorta in an immature female. Four small follieles are present. 60×.

FIG. 2. Hyperplastic thyroid tissue around the ventral aorta, in the floor of the pharynx, and in the gills of an immature female. The follicles are greatly increased in size and in number. 60×.

FIG. 3. Hyperplastic thyroid tissue in the gills of the same fish, 300×.

FIG. 4. High power view of hyperplastic thyroid tissue. 970×.

PLATE II

Xiphophorus variatus variatus

FIG. 5. Thyroid tissue around the ventral aorta in tumorous specimen. 140×.

FIG. 6. Heterotopic thyroid tissue in the spleen and body cavity of same fish. 100×.

FIG. 7. Detailed view of thyroid follicles in the spleen and body cavity. 290×.